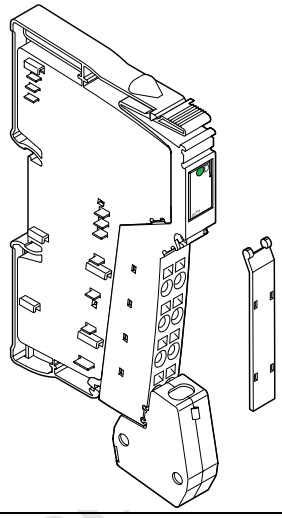
IB IL TEMP 2 UTH (-PAC)



Inline Terminal With 2 Analog Input Channels for Thermocouple Connection

AUTOMATIONWORX

Data Sheet
5722_en_03

1 Description

The terminal is designed for use within an Inline station. Signals of standard thermocouples can be detected using this terminal.
13 different types of thermocouples are supported in accordance with DIN EN 60584-1 and DIN 43710 as well as a linear voltage input of -15 mV up to +85 mV.

Features

- 2 differential inputs for thermocouples or linear voltage; 1 input for an external Pt1000 or Ni1000 cold junction.
- Configuration of channels via the bus system
- Internal detection of cold junction temperature (configurable)
- Absolute or differential temperature measurement (configurable)
- Pt1000 sensor in the vicinity of the connection terminals of the thermocouple inputs for internal measurement of the cold junction temperature
- Measured values can be represented in 3 different formats
- Approved for the use in potentially explosive areas (observe the notes on page 7)

This data sheet is only valid in association with the IL SYS INST UM E user manual or the Inline system manual for your bus system.

Make sure you always use the latest documentation.
It can be downloaded at www.download.phoenixcontact.com.

A conversion table is available on the Internet at
www.download.phoenixcontact.com/general/7000_en_00.pdf.

This data sheet is valid for the following products listed under "Ordering Data" on page 3.

Table of Contents

2 Ordering Data

Products

Description	Type	Order No.	Pcs./Pkt.
Inline terminal with 2 analog input channels for temperature measurement; complete with accessories (connector with labeling field)	IB IL TEMP 2 UTH-PAC	2861386	1
Inline terminal with 2 analog input channels for temperature measurement; without accessories	IB IL TEMP 2 UTH	2727763	1

The connector listed below is needed for the complete fitting of the IB IL TEMP 2 UTH terminal.

Accessories

Description	Type	Order No.	Pcs./Pkt.
Inline shield connector for analog Inline terminals	IB IL SCN-6 SHIELD TWIN	2740245	5
Thermoelectric voltage terminal block pair for equalizing conductor extension			
Thermoelectric voltage terminal block pair for CU/CUNI44 copper/constantan	MTKD-CU/CUNI	3100059	
Thermoelectric voltage terminal block pair for FE/CUNI44 iron-constantan	MTKD-FE/CUNI	3100046	
Thermoelectric voltage terminal block pair for NICR/CUNI44 nichrome-constantan	MTKD-NICR/CUNI	3100075	
Thermoelectric voltage terminal block pair for NICR/NI nichrome-nickel	MTKD-NICR/NI	3100062	
Thermoelectric voltage terminal block pair for E-CU/A-CU copper/cupro-nickel	MTKD-E-CU/A-CU	3100091	
Thermoelectric voltage terminal block pair for S-CU/E-CU S-copper/copper	MTKD-S-CU/E-CU	3100101	

Documentation

Description	Type	Order No.	Pcs./Pkt.
"Automation Terminals of the Inline Product Range" user manual	IL SYS INST UM E	2698737	
"Configuring and Installing the INTERBUS Inline Product Range" user manual	IB IL SYS PRO UM E	2743048	1
"INTERBUS Addressing" data sheet	DB GB IBS SYS ADDRESS	9000990	1
"Inline Terminals for Use in Zone 2 Potentially Explosive Areas" application note	AH EN IL EX ZONE 2	7217	1

3 Technical Data

General Data	
Housing dimensions (width x height x depth)	12.2 mm x 120 mm x 71.5 mm
Weight	46 g (without connector) / 67 g (with connector)
Operating mode	Process data mode with 2 words
Transmission speed	500 kbps
Connection method for sensors	2-wire technology
Ambient temperature (operation)	-25°C to +55°C
Ambient temperature (storage/transport)	-25°C to +85°C
Permissible humidity (operation/storage/transport)	10% to 95% according to DIN EN 61131-2
Permissible air pressure (operation/storage/transport)	70 kPa to 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20 according to IEC 60529
Class of protection	Class 3 according to EN 61131-2, IEC 61131-2
Connection data for Inline connectors	
Connection type	Spring-cage terminals
Conductor cross-section	0.2 mm^2 to 1.5 mm^2 (solid or stranded), 24 - 16 AWG

Interface	
Local bus	Through data routing

Supply of the Module Electronics and I/O Through Bus Coupler/Power Terminal	
Connection method	Potential routing

Power Consumption	
Communications power U_L	7.5 V
Current consumption at U_L	43 mA (typical)
Analog supply voltage U_{ANA}	24 V DC
Current consumption at U_{ANA}	11 mA (typical)
Total power consumption	590 mW (typical)

Analog Inputs	
Number	2 inputs for thermocouples or linear voltage
Connection of the signals	2-wire, shielded equalizing conductor for TC with encapsulated sensors
Cable length	Shorter than 30 m for shielded cables
Sensor types that can be used	B, C, E, J, K, L, N, R, S, T, U, W, HK
Characteristics standards	DIN EN 60584-1: 1995 (B, E, J, K, N, R, S, T) DIN 43710 (U, L)
Voltage input range	-15 mV up to +85 mV
Termperature measuring unit	Either Celsius, Fahrenheit or µV scale
Temperature measuring range	See Table on page 19
Resolution in the process data word (quantization)	Configurable, see Tableon page 13
Resolution of measuring values	See Table page 18
Measured value representation	In the formats Format 1 (IB standard) (15 bits with sign bit) Format 2 (12 bits with sign bit) Format 3 (15 bits with sign bit)
Conversion procedure of the analog/digital converter	Successive approximation
Conversion time of the analog/digital converter	120 µs, typical
Process data update	30 ms, maximum, for both channels
Limit frequency of the analog filter	48 Hz

Safety Equipment	
Surge proof up to ±40 V	TC channels: Connections 1.2 and 2.2 as well as 1.3. and 2.3

Electrical Isolation/Isolation of the Voltage Areas

Common Potentials

24 V main voltage U_M, 24 V segment voltage U_S, and GND have the same potential. FE is a separate potential area.

Separate Potentials in the System Consisting of Bus Terminal Module/Power Terminal and Analog I/O Terminal

Test Distance	Test Voltage
5 V supply incoming remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min
5 V supply outgoing remote bus/7.5 V supply (bus logic)	500 V AC, 50 Hz, 1 min
7.5 V supply (bus logic) / 24 V supply (I/O)	500 V AC, 50 Hz, 1 min
7.5 V supply (bus logic) / 24 V analog supply (analog I/O)	500 V AC, 50 Hz, 1 min
24 V supply (I/O) / functional earth ground	500 V AC, 50 Hz, 1 min
24 V analog supply (analog I/O) / functional earth ground	500 V AC, 50 Hz, 1 min

Error Messages to the Higher-Level Control or Computer System

Failure of the internal voltage supply	Yes
Failure of or insufficient communications power U_L	Yes, I/O error message sent to the bus terminal
Peripheral fault/user error	Yes, error message via the process data input words (see page 14)

Approvals

For the latest approvals, please visit www.download.phoenixcontact.com or www.eshop.phoenixcontact.com.

4 Local Diagnostic Indicators and Terminal Point Assignment

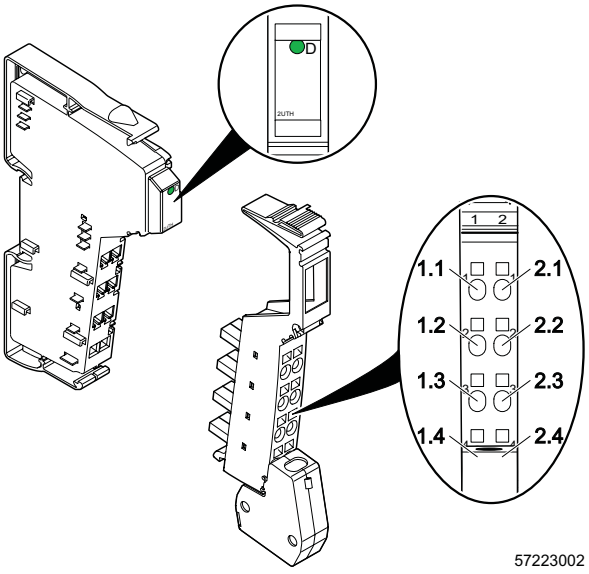


Figure 1 Terminal with appropriate connector

4.1 Local Diagnostic Indicator

Des.	Color	Meaning
D	Green	Diagnostics

4.2 Function Identification

Green

4.3 Terminal Point Assignment

Terminal Points	Signal	Assignment
1.1	**RTD_{EXT+}**	Optional (for lab applications only) external cold junction sensor (Pt1000, Ni1000) (plus input)
2.1	**RTD_{EXT-}**	Optional (for lab applications only) external cold junction sensor (Pt1000, Ni1000) (minus input)
1.2	**TC+**	Thermocouple (plus input) channel 2
2.2	**TC-**	Thermocouple (minus input) channel 2
1.3	**TC+**	Thermocouple (plus input) channel 1
2.3	**TC-**	Thermocouple (minus input) channel 1
1.4, 2.4	**Shield**	Shield connection (channel 1 and 2)

5 Installation Instructions

High current flowing through potential jumpers U_M and U_S leads to a temperature rise in the potential jumpers and inside the terminal. Observe the following instructions to keep the current flowing through the potential jumpers of the analog terminals as low as possible:

Create a separate main circuit for all analog terminals.

If this is not possible in your application and if you are using analog terminals in a main circuit together with other terminals, place the analog terminals after all the other terminals at the end of the main circuit.

Regarding this terminal, please also observe that via potential routing the current always distorts the temperature of the internal cold junction. Therefore, position this terminal after **all** of the other terminals to minimize the current flowing through **all** potential jumpers.

6 Notes on Using the Terminal in Potentially Explosive Areas

Approval According to EC Directive 94/9 (ATEX)
II 3G Ex nAC IIC T4 X

This Inline terminal conforms to the requirements of protection type "n" and can be installed in a zone 2 potentially explosive area. This Inline terminal is a category 3G item of electrical equipment.

WARNING: Explosion hazard
Only Inline terminals that are approved for use in potentially explosive areas may be snapped next to this Inline terminal.

Before using an Inline terminal in a zone 2 potentially explosive area, check that the terminal has been approved for installation in this area.

For a list of terminals approved for zone 2 potentially explosive areas, please refer to the AH EN IL EX ZONE 2 application note.

Check the labeling on the Inline terminal and the packaging (see Figure 2).

Figure 2 Typical labeling of terminals for use in potentially explosive areas

WARNING: Explosion hazard

Before startup, ensure that the following points and instructions are observed.

1. When working on the Inline terminal, always disconnect the supply voltage.
2. The Inline terminal must only be installed, started up, and maintained by qualified specialist personnel.
3. Install the Inline terminals in a control cabinet or metal housing. The minimum requirement for both items is IP54 protection according to EN 60529.
4. The Inline terminal must not be subject to mechanical strain and thermal loads, which exceed the limits specified in the product documentation.
5. The Inline terminal must not be repaired by the user. Repairs may only be carried out by the manufacturer. The Inline terminal is to be replaced by an approved terminal of the same type.
6. Only category 3G equipment may be connected to Inline terminals in zone 2.
7. Observe all applicable standards and national safety and accident prevention regulations for installing and operating equipment.

Restrictions

WARNING: Explosion hazard

When using terminals in potentially explosive areas, observe the technical data and limit values specified in the corresponding documentation (user manual, data sheet, package slip).

WARNING: Explosion hazard
Restrictions regarding the Inline system

The **maximum permissible current** flowing through the potential jumpers U_M and U_S (total current) is limited to **4 A** when using the Inline terminal in potentially explosive areas.

7 Internal Circuit Diagram

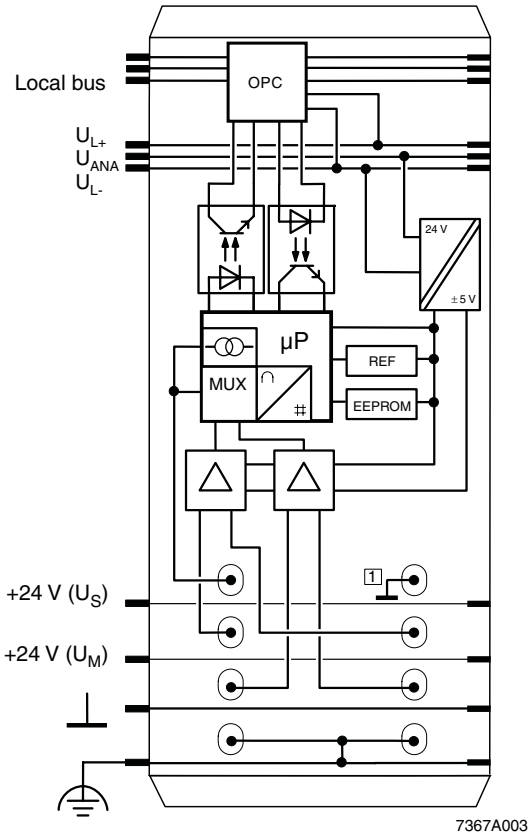
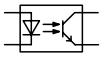


Figure 3 Internal wiring of the terminal points

Key:

Protocol chip



Optocoupler

DC/DC converter with electrical isolation

Microprocessor with multiplexer, power source for the cold junction and analog/digital converter

Reference voltage

Electrically erasable programmable read-only memory

Amplifier

Analog ground, electrically isolated from ground of the potential jumper

Other symbols used are explained in the IL SYS INST UM E user manual or in the Inline system manual for your bus system.

8 Electrical Isolation

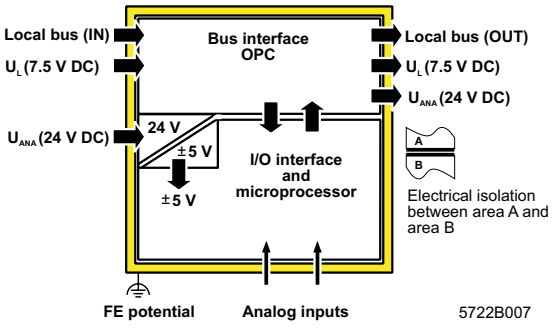


Figure 4 Electrical isolation of the individual function areas

9 Connection Notes

Thermocouple Connection

Always connect the thermocouples using shielded, and twisted pair cables.

Use encapsulated thermocouples.

For thermocable extension, thermoelectric voltage terminal blocks are available (Phoenix Contact MTKD type; see Figure 7 on page 10 and ordering data).

Shield Connection

The connection examples show how to connect the shield (Figure 5 to Figure 7).

Connect the shielding to only one side of the Inline terminal using the shield connection clamp. In this way, the creation earth loops that might occur when connecting the shielding to PE can be prevented. The clamp connects the shield directly to FE on the module side. Additional wiring is not necessary.

Insulate the shield at the sensor.

10 Connection Examples

When connecting the shield at the terminal you must insulate the shield on the sensor side (shown in gray in Figure 5 and Figure 6).

Use a connector with shield connection when installing the sensors. Figure 5 and Figure 6 show the connection schematically (without shield connector).

10.1 Absolute Temperature Measurement

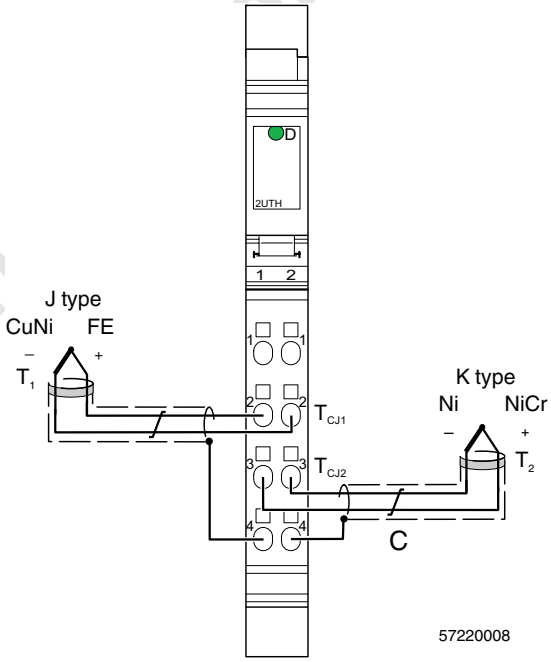


Figure 5 Absolute temperature measurement at 2 channels

For absolute temperature measurement, the measuring temperature of T_1 or T_2 is determined via cold junction compensation (T_{CJ1}, T_{CJ2}).

10.2 Differential Temperature Measurement

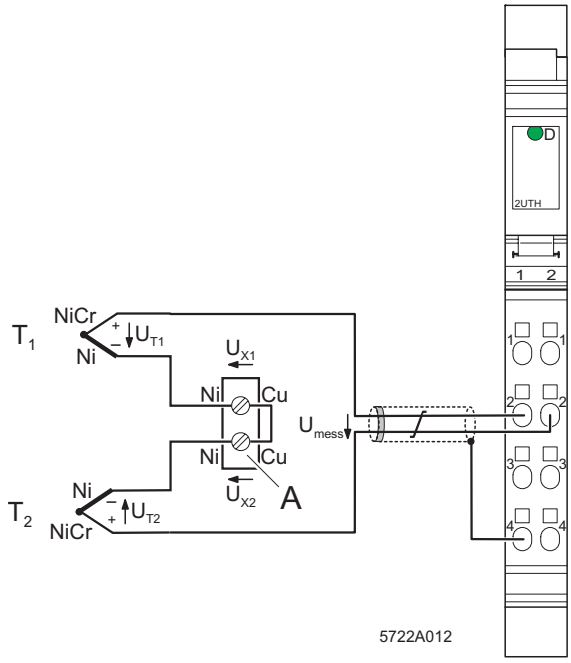


Figure 6 Differential temperature measurement using 2 thermocouples, type K

$U_{meas} = U_{T1} - U_{X1} + U_{X2} - U_{T2} = U_{T1} - U_{T2}$

The absolute value of U_{X1} equals U_{X2}, the prerequisite being that both terminal points (A) are on the same temperature level. Both voltages compensate each other. It is the difference between U_{T1} and U_{T2} that remains.

10.3 Equalizing Conductor Extension

When connecting the shield to a central grounding point, you must insulate the shield at the opposite side (shown in gray in Figure 7).

Use a connector with shield connection when installing the sensors. Figure 7 shows the connection schematically (without shield connector).

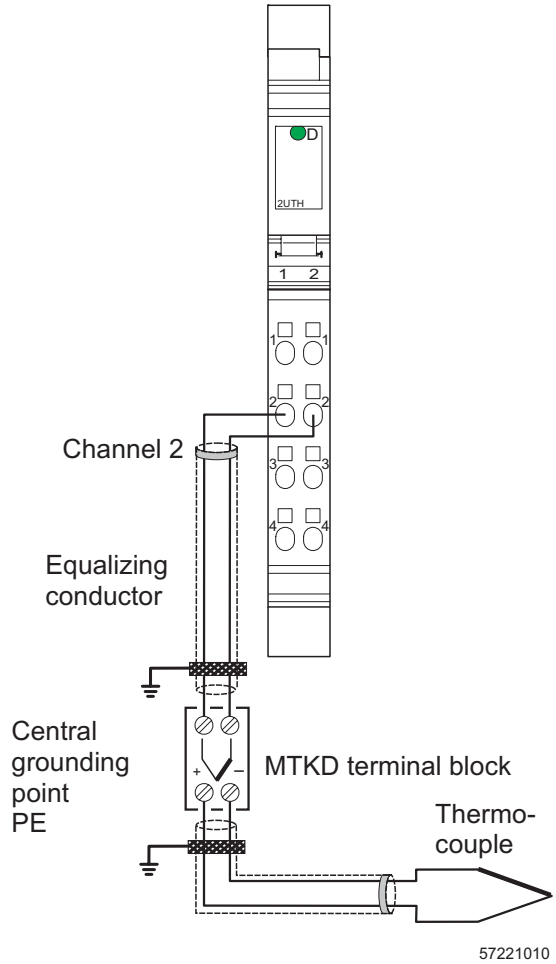


Figure 7 Equalizing conductor extension using thermocouples

11 Programming Data/Configuration Data

Local Bus (INTERBUS)

ID code	$7F_{hex}$ (127_{dec})
Length code	02_{hex}
Process data channel	32 bits
Input address area	2 words
Output address area	2 words
Parameter channel (PCP)	0 words
Register length (bus)	2 words

Other Bus Systems

For the programming/configuration data of other bus systems, please refer to the corresponding electronic device data sheet (e.g., GSD, EDS).

12 Process Data

For the assignment of the illustrated (byte.bit) view to your **INTERBUS** control or computer system, please refer to the DB GB IBS SYS ADDRESS data sheet.

12.1 Output Data For Configuration of the Terminal (See page 12)

(Word.bit) view	Word	Word 0															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Channel 1	Assignment	1	0	0	0	0	0	0	CJ	Resolution		Format		Sensor Type			

(Word.bit) view	Word	Word 1															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 2								Byte 3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Channel 2	Assignment	1	0	0	0	0	0	0	CJ	Resolution		Format		Sensor Type			

CJ Cold junction

12.2 Assignment of the Terminal Points to the Input Data (See page 14)

(Word.bit) view	Word	Word 0															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 0								Byte 1							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Channel 1	Signal	Terminal point 1.2															
	Signal reference	Terminal point 2.2															
	Shielding	Terminal point 1.4, 2.4															

(Word.bit) view	Word	Word 1															
	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
(Byte.bit) view	Byte	Byte 2								Byte 3							
	Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Channel 2	Signal	Terminal point 1.3															
	Signal reference	Terminal point 2.3															
	Shielding	Terminal point 1.4, 2.4															

12.3 Process Data Output Words (OUT)

The terminal channels can be configured using the two process data output words. The following configuration options exist for each channel independent of the other channel:

– Sensor type selection
– Resolution settings
– Switching between the measured value representation formats
– Selecting the cold junction

The configuration setting is not stored. It must be transmitted in every bus cycle.

After applying voltage (power up) to the Inline station, the "Measured value invalid" message (error code 8004_{hex}) appears in the IN process data.

After 1 s (maximum) the preset configuration is accepted and the first measured value is available. If you change the configuration, the corresponding channel is re-initialized. The "Measured value invalid" message (error code 8004_{hex}) appears in the OUT process data for 100 ms, maximum.

Default:

Sensor type:	TC Type K
Resolution:	0.1°C (1µV)
Output format:	Format 1 (IB standard)
Cold junction	Internal

One process data output word is available for the configuration of each channel.

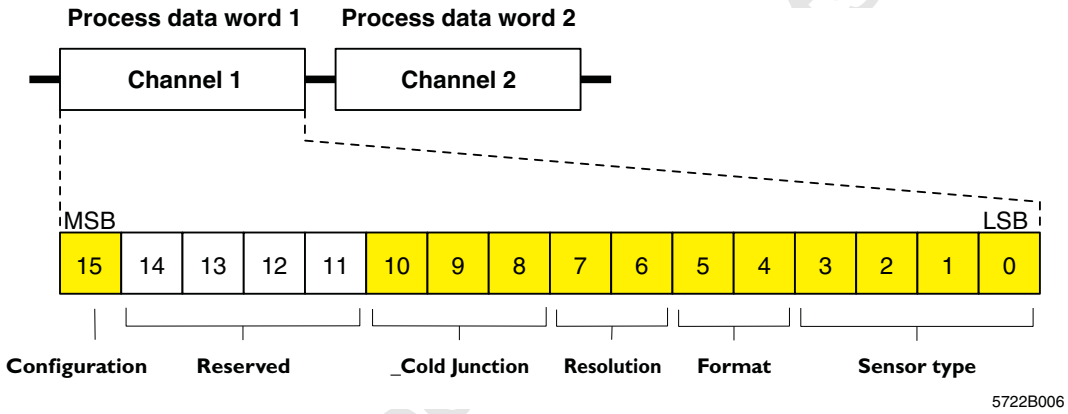


Figure 8 Process data output words

Set all reserved bits to 0.

In order to configure the terminal, set bit 15 of the corresponding output word to 1. If bit 15 = 0, the pre-set configuration is active.

Bit 15:

Code		Configuration
dec	bin	
0	**0**	**Default**
1	1	Configuration Data

Bit 10 to Bit 8:

Code		Cold Junction Compensation
dec	bin	
0	**000**	**Internal cold junction active;** TC measurement with internal cold junction compensation
1	001	Internal cold junction inactive; TC differential measurement without cold junction compensation
2	010	External cold junction Pt1000; TC measurement with external cold junction compensation at an isothermal block (**for lab applications only**).
3	011	External cold junction Ni1000; TC measurement with external cold junction compensation at an isothermal block (**for lab applications only**).
4 to 7	100 to 111	Reserved

Bit 7 and Bit 6:

Code		Resolution (Referring to Format 1 (IB Standard))
dec	bin	
0	**00**	**0.1°C (1 µV)**
1	01	1°C (10 µV)
2	10	0.1°F
3	11	1°F

Bit 5 and Bit 4:

Code		Format
dec	bin	
0	**00**	**Format 1: IB standard** **15 bit + sign bit with extended diagnostics**
1	01	Format 2: 12 bits + sign bit + 3 diagnostic bits
2	10	Format 3: 15 bits + sign bit
3	11	Reserved

Bit 3 to Bit 0:

Code		Sensor Type
dec	bin	
0	**0000**	**TC Type K**
1	0001	TC Type J
2	0010	TC Type E
3	0011	TC Type R
4	0100	TC Type S
5	0101	TC Type T
6	0110	TC Type B
7	0111	TC Type N
8	1000	TC Type U
9	1001	TC Type L
10	1010	TC Type C
11	1011	TC Type W
12	1100	TC Type HK
13	1101	Cold junction
14	1110	U: Voltage (-15 mV up to +85 mV)
15	1111	Reserved

Use sensor type 14 to represent the measured values (linear voltage) of the IB standard format.

If you select the cold junction as sensor type, the input data word displays the cold junction temperature (terminal temperature). Furthermore, the channel configured in this way is not evaluated in the frame of the measuring cycle so that the update time for the terminal is shortened.

12.4 Process Data Input Words (IN)

On each channel the measured values are transmitted to the controller board or the computer by means of the IN process data words.

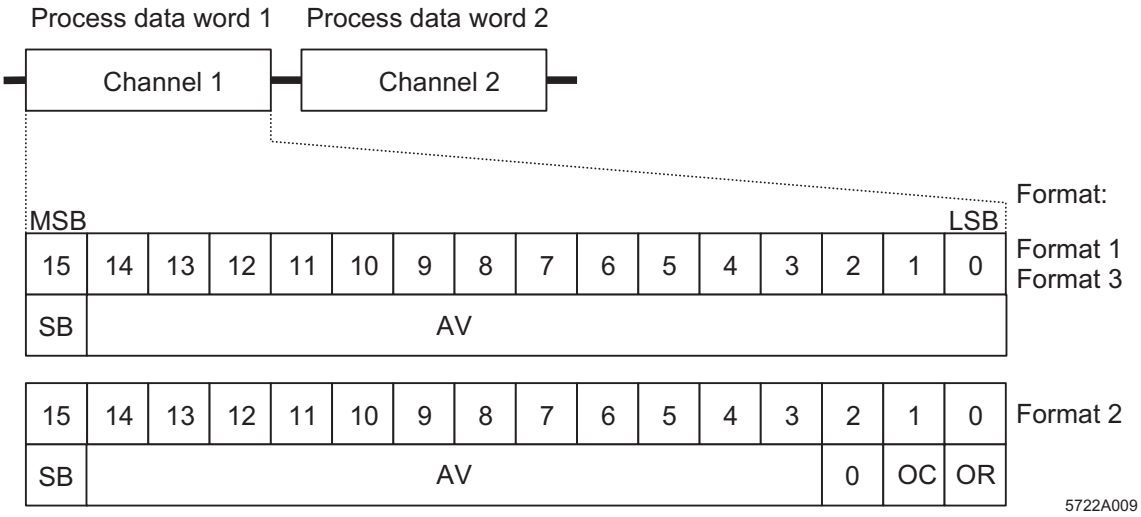


Figure 9 Sequence of the process data input words and display of the bits of the first process data word in the different formats

Key

MSB	Most significant bit
LSB	Least significant bit
SB	Sign bit
AV	Analog value
0	Reserved
OC	Open circuit
OR	Overrange

The process data format 1 (IB standard) supports extended diagnostics.
The following error codes are possible:

Code (hex)	Errors
8001	Overrange
8002	Open circuit
8004	Measured value invalid/no valid measured value available
8008	Cold junction defective
8010	Invalid configuration
8040	Terminal faulty
8080	Underrange

13 Formats for the Representation of Measured Values

13.1 Format 1: IB Standard

The measured value is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

This format supports extended diagnostics. Values > 8000_{hex} indicate an error. The error codes are listed on page 14.

Measured value representation in format 1 (IB standard; 15 bits)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	AV														

SB Sign bit
AV Analog value

Typical Analog Values Depending on the Resolution

Sensor Type (Bits 3 to 0)		**TC and CJ Sensor (0 to 13)**	**Linear Voltage (14)**
Resolution (Bits 7 and 6)		**00_{bin} / 10_{bin}**	**00_{bin}**
Process Data Item$_{hex}$ (= Analog Value$_{hex}$)	**Analog Value$_{dec}$**	**0.1°C / 0.1°F (°C) / (°F)**	**1 µV (µV)**
8002		*Open circuit*	–
8001		*Overrange*	*> 32512*
2710	10000	1000.0	10000
000A	10	1.0	10
0001	1	0.1	1
0000	0	0	0
FFFF	-1	-0.1	-1
FC18	-1000	-100.0	-1000
C568	-15000	–	-15000
8080		*Underrange*	*< -15000*

Sensor Type (Bits 3 to 0)		**TC and CJ Sensor (0 to 13)**	**Linear Voltage (14)**
Resolution (Bits 7 and 6)		**01_{bin} / 11_{bin}**	**01_{bin}**
Process Data Item$_{hex}$ (= Analog Value$_{hex}$)	**Analog Value$_{dec}$**	**1°C / 1°F (°C) / (°F)**	**10 µV (µV)**
8002		*Open circuit*	–
8001		*Overrange*	*> 85000*
2134	8500	–	85000
03E8	1000	1000	10000
0001	1	1	10
0000	0	0	0
FFFF	-1	-1	-10
FF9C	-100	-100	-1000
FA24	-1500	–	-15000
8080		*Underrange*	*< -15000*

If the measured value is larger than the representation range of the process data, the "Overrange" or "Underrange" error codes are generated.

The "open circuit" error message is only generated in TC operation.

13.2 Format 2

The measured value is represented in bits 14 to 3. The remaining 4 bits are sign and error bits.

Measured value representation in format 2 (12 bits)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	AV												0	OC	OR

SB	Sign bit
AV	Analog value
0	Reserved
OC	Open circuit/short circuit
OR	Overrange

Typical Analog Values Depending on the Resolution

Sensor Type (Bits 3 to 0)		**TC and CJ Sensor (0 to 13)**	
Resolution (Bits 7 and 6)		**00_{bin} / 10_{bin}**	**01_{bin} / 11_{bin}**
Process Data Item$_{hex}$ (= Analog Value$_{hex}$)	**Analog Value$_{dec}$**	**0.1°C / 0.1°F (°C) / (°F)**	**1°C / 1°F (°C) / (°F)**
xxxx xxxx xxxx xxx1$_{bin}$		*Overrange* (AV = positive final value from the table on page 19)	
2710	10000	1000	–
03E8	1000	100	1000
0008	8	0.8	8
0000	0	0	0
FFF8	-8	-0.8	-8
FC18	-1000	-100	–
xxxx xxxx xxxx xxx1$_{bin}$		*Underrange* (AV = negative final value from the table on page 19)	
xxxx xxxx xxxx xx1x$_{bin}$		*Open circuit* (AV = negative final value from the table on page 19)	

AV	Analog value
x	Can accept values 0 or 1

If the measured value is larger than the representation range of the process data, bit 0 is set to 1.

For an open circuit bit 1 is set to 1.

13.3 Format 3

The measured value is represented in bits 14 to 0. An additional bit (bit 15) is available as a sign bit.

Measured value representation in format 3 (15 bits)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SB	AV														

SB Sign bit

AV Analog value

Typical Analog Values Depending on the Resolution

Sensor Type (Bits 3 to 0)		**TC and CJ Sensor (0 to 13)**
Resolution (Bits 7 and 6)		**00_{bin} / 10_{bin}**
Process Data Item$_{hex}$ (= Analog Value$_{hex}$)	**Analog Value$_{dec}$**	**0.1°C / 0.1°F (°C) / (°F)**
Upper limit value + 1 LSB*		*Overrange*
7D00	32000	–
2710	10000	1000.0
000A	10	1
0001	1	0.1
0000	0	0
FFFF	-1	-0.1
FC18	-1000	-100.0
B500	-19200	–
Lower limit value - 1 LSB*		*Underrange*
Lower limit value - 2 LSB*		*Open circuit*

Sensor Type (Bits 3 to 0)		**TC and CJ Sensor (0 to 13)**
Resolution (Bits 7 and 6)		**01_{bin} / 11_{bin}**
Process Data Item$_{hex}$ (= Analog Value$_{hex}$)	**Analog Value$_{dec}$**	**1°C / 1°F (°C) / (°F)**
Upper limit value + 1 LSB*		*Overrange*
6400	25600	–
03E8	1000	1000
0001	1	1
0000	0	0
FFFF	-1	-1
FF9C	-100	-100
ED40	-4800	–
Lower limit value - 1 LSB*		*Underrange*
Lower limit value - 2 LSB*		*Open circuit*

* The limit values are given in the table on page 19

14 Measuring Ranges

14.1 Measuring Range Depending on the Resolution (Format 1 (IB Standard) and Format 3)

Resolution (Bits 7 and 6)	Thermocouples	Linear Voltage Sensors
00	-273°C up to +3276.8°C resolution: 0.1°C	-15 mV up to +32.7768 mV resolution: 1 µV
01	-273°C up to +32768°C resolution: 1.0°C	-15 mV up to +85 mV resolution: 10 µV
10	-459°F up to +3276.8°F resolution: 0.1°F	
11	-459°F up to +32768°F resolution: 1.0°F	

14.2 Measuring Ranges Depending on the Resolution (Format 2)

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Resolution (Bits 7 and 6)	Thermocouples
00	-272.8°C up to +3276.0°C resolution: 0.8°C
01	-272°C up to +32760°C resolution: 8°C
10	-459.2°F up to +3276°F resolution: 0.8°F
11	-456°F up to +32760°F resolution: 8°F

Temperature values can be converted from °C to °F according to the following formula:

$$T\,[°F] = T\,[°C] \times \frac{9}{5} + 32$$

Where:

T [°F] Temperature in degrees Fahrenheit

T [°C] Temperature in degrees Celsius

14.3 Input Measuring Values

No.	Input	Sensor Type	Standard	Measuring Range (Software-Supported)	
				Lower Limit	Upper Limit
1	Thermocouples	B	EN 60584-1 (DIN EN 60584-1)	+50°C +122°F	+1820°C +3308°F
2		E		-270°C -454°F	+1000°C +1832°F
3		J		-210°C -346°F	+1200°C +2192°F
4		K		-270°C -454°F	+1372°C +2501°F
5		N		-270°C -454°F	+1300°C +2372°F
6		R		-50°C -58°F	+1768°C +3214°F
7		S		-50°C -58°F	+1768°C +3214°F
8		T		-270°C -454°F	+400°C +752°F
9		C		-18°C 0°F	+2316°C +4200°F
10		W		-18°C 0°F	+2316°C +4200°F
11		HK		-200°C -328°F	+800°C +1472°F
12		L	DIN 43710	-200°C -328°F	+900°C +1652°F
13		U		-200°C -328°F	+600°C +1112°F
14	Internal cold junction	Pt1000	DIN IEC 60751	-200°C	+850°C
15	Voltage input	Linear voltage signal		-15 mV	+85 mV

For under and overrange of the limits indicated above, the "Over-/Underrange" error message is generated in the "IB standard" format 1.

15 Tolerance and Temperature Response

15.1 Tolerances at an Ambient Temperature T_A = +25°C

No.	Input	Sensor Type	Measuring Range for Tolerance Data*	Relative Error	Absolute Error	Maximum Relative Error	Maximum Absolute Error
1	Thermocouples	B	+500°C up to +1820°C* +932°F up to +3308°F	±0.23%	±4.2 K	±0.92%	±16.7 K
2		E	-226°C up to +1000°C* -374.8°F up to +1832°F	±0.04%	±0.4 K	±0.15%	±1.6 K
3		J	-210°C up to +1200°C* -346°F up to +2192°F	±0.04%	±0.5 K	±0.15%	±1.9 K
4		K	-200°C up to +1372°C* -328°F up to +2501°F	±0.04%	±0.6 K	±0.17%	±2.4 K
5		N	-200°C up to +1300°C* -328°F up to +2372°F	±0.07%	±1.0 K	±0.29%	±3.7 K
6		R	-50°C up to +1768°C -58°F up to +3214°F	±0.14%	±2.5 K	±0.57%	±10.0 K
7		S	-50°C up to +1768°C -58°F up to +3214°F	±0.14%	±2.5 K	±0.57%	±10.0 K
8		T	-270°C up to +400°C -454°F up to +752°F	±0.16%	±0.7 K	±0.63%	±2.5 K
9		C	-18°C up to +2316°C 0°F up to +4200°F	±0.07%	±1.7 K	±0.29%	±6.7 K
10		W	-18°C up to +2316°C 0°F up to +4200°F	±0.09%	±2.1 K	±0.36%	±8.4 K
11		HK	-200°C up to +800°C -328°F up to 1472°F	±0.05%	±0.4 K	±0.18%	±1.5 K
12		L	-200°C up to +900°C -328°F up to +1652°F	±0.05%	±0.5 K	±0.21%	±1.9 K
13		U	-200°C up to +600°C -328°F up to +1112°F	±0.11%	±0.7 K	±0.42%	±2.5 K
14	Internal cold junction	Pt1000	-25°C to +85°C	±0.04%	±0.3 K	±0.22%	±1.9 K
15	Voltage input	Linear signals	-15 mV up to +85 mV	±0.03%	±25 µV	±0.12%	±100 µV

All percentage values refer to the relevant measuring range final value.

* Below the indicated range, more errors are to be expected because of the low sensitivity of the sensor elements.

The tolerance indications of the TC sensors refer to a differential temperature measurement without cold junction compensation. In addition, the tolerances of the sensor element and the cold junction must be considered (see table on page 22).

15.2 Tolerances at an Ambient Temperature T_A = -25°C up to +55°C

No.	Input	Sensor Type	Measuring Range for Tolerance Data*	Relative Error	Absolute Error	Maximum Relative Error	Maximum Absolute Error
1	Thermocouples	B	+500°C up to +1820°C* +932°F up to +3308°F	±0.55%	±10.0 K	±1.37%	±25.0 K
2		E	-226°C up to +1000°C* -374.8°F up to +1832°F	±0.09%	±0.9 K	±0.23%	±2.3 K
3		J	-210°C up to +1200°C* -346°F up to +2192°F	±0.09%	±1.1 K	±0.23%	±2.8 K
4		K	-200°C up to +1372°C* -328°F up to +2501°F	±0.10%	±1.4 K	±0.26%	±3.6 K
5		N	-200°C up to +1300°C* -328°F up to +2372°F	±0.17%	±2.2 K	±0.43%	±5.6 K
6		R	-50°C up to +1768°C -58°F up to +3214°F	±0.34%	±6.0 K	±0.85%	±15.0 K
7		S	-50°C up to +1768°C -58°F up to +3214°F	±0.34%	±6.0 K	±0.85%	±15.0 K
8		T	-270°C up to +400°C -454°F up to +752°F	±0.38%	±1.5 K	±0.95%	±3.8 K
9		C	-18°C up to +2316°C 0°F up to +4200°F	±0.17%	±4.0 K	±0.43%	±10.0 K
10		W	-18°C up to +2316°C 0°F up to +4200°F	±0.22%	±5.0 K	±0.54%	±12.5 K
11		HK	-200°C up to +800°C -328°F up to 1472°F	±0.11%	±0.9 K	±0.28%	±2.2 K
12		L	-200°C up to +900°C -328°F up to +1652°F	±0.12%	±1.1 K	±0.31%	±2.8 K
13		U	-200°C up to +600°C -328°F up to +1112°F	±0.25%	±1.5 K	±0.63%	±3.8 K
14	Internal cold junction	Pt1000	-25°C to +85°C	±0.05%	±0.4 K	±0.24%	±2.0 K
15	Voltage input	Linear signals	-15 mV up to +85 mV	±0.07%	±60 µV	±0.18%	±150 µV

All percentage values refer to the relevant measuring range final value.

* Below the indicated range, more errors are to be expected because of the low sensitivity of the sensor elements.

The tolerance indications of the TC sensors refer to a differential temperature measurement without cold junction compensation. In addition, the tolerances of the sensor element and the cold junction must be considered (see table on page 22).

15.3 Temperature Behavior

No.	Input	Sensor Type	Measuring Range for Tolerance Data	Typical Drift	Maximum Drift
15	Voltage input	Linear signals	-15 mV up to +85 mV	15 ppm/K	35 ppm/K

15.4 Tolerances of the Internal Cold Junction

Operation at an Ambient Temperature T_A = -25°C up to +55°C

No.	Error Type	Typical	Maximum
1	Sensor tolerance Pt1000 (T_A = 25°C)	±0.2 K	±0.43 K
2	Temperature distribution tolerances (channel 1 and channel 2)	–	–
3	Linearity error due to linearization	±0.01 K	±0.01 K
4	**Total error of the cold junction for T_A = 25°C**	**±0.3 K**	**±1.9 K**
5	**Total error of the cold junction for T_A = -25°C up to +55°C**	**±0.4 K**	**±2.0 K**

After supplying the voltage, the warm up time lasts approximately 30 minutes. Directly after startup, the tolerances of the cold junction can be increased by the typical tolerance.

The curve displaying the transient response, is shown in Figure 10.

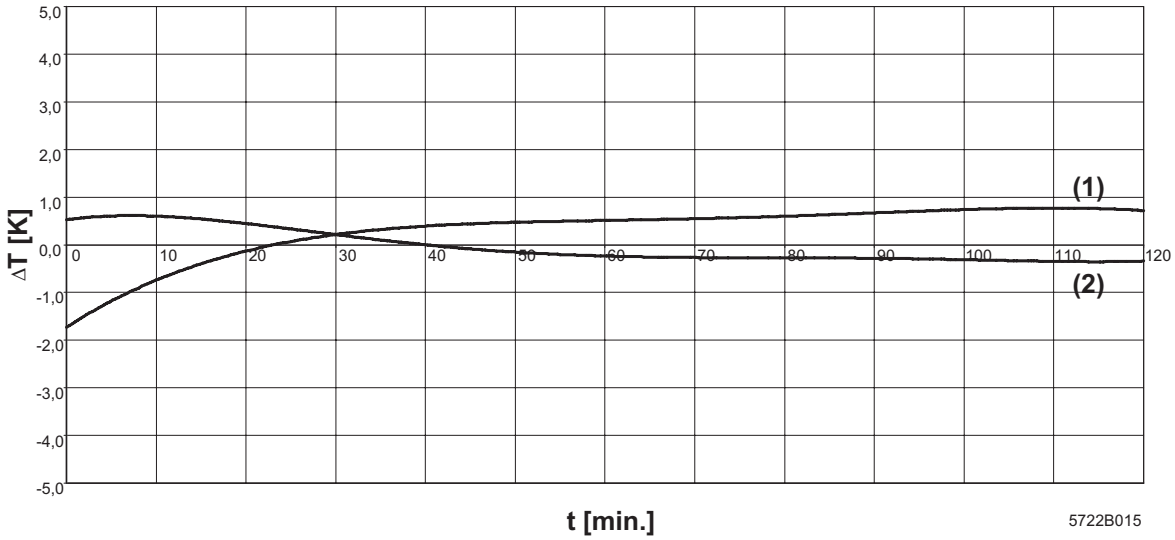

Figure 10 Transient response of the IB IL TEMP 2 UTH terminal

t [min]	Time after switching on in minutes
ΔT [K]	Temperature deviation from the measured value in Kelvin (absolute error) The total system erorr for an absolute temperature measurement - as displayed in Figure 10 - comprises the sensor tolerance, the device error and the cold junction error.
(1)	Curve for channel 1
(2)	Curve for channel 2

15.5 Tolerances Due to Linearization

No.	Input	Sensor Type	Standard	Measuring Range (Software-Supported)	Maximum Error Due to Sensor Linearization
1	Thermocouples	B	EN 60584-1 (DIN EN 60584-1)	+50°C up to +1820°C +122°F up to +3308°F	±0.05 K
2		E		-270°C up to +1000°C -454°F up to +1832°F	±0.05 K
3		J		-210°C up to +1200°C -346°F up to +2192°F	±0.05 K
4		K		-270°C up to +1372°C -454°F up to +2501°F	±0.05 K
5		N		-270°C up to +1300°C -454°F up to +2372°F	±0.05 K
6		R		-50°C up to +1768°C -58°F up to +3214°F	±0.05 K
7		S		-50°C up to +1768°C -58°F up to +3214°F	±0.05 K
8		T		-270°C up to +400°C -454°F up to +752°F	±0.05 K
9		C		-18°C up to +2316°C 0°F up to +4200°F	±0.1 K
10		W		-18°C up to +2316°C 0°F up to +4200°F	±0.1 K
11		HK		-200°C up to +800°C -328°F up to 1472°F	±0.1 K
12		L	DIN 43710	-200°C up to +900°C -328°F up to 1652°F	±0.05 K
13		U		-200°C up to 600°C -328°F up to 1112°F	±0.05 K
14	Internal cold junction	Pt1000		-200°C up to +850°C -328°F up to 1562°F	±0.01 K
15	Voltage input	Linear signals		–	–

15.6 Additional Tolerances When Subject to EMI

Type of Electromagnetic Interference	Typical Relative Deviation of the Measuring Range Final Value	Criterion
Electromagnetic fields according to IEC 61000-4-3; EN 61000-4-3; field strength 10 V/m	Channel 1: ±9.6% Channel 2: ±5.0%	A
Conducted interferences (0.15 MHz up to 80 MHz) according to IEC 61000-4-6; EN 61000-4-6; class 3 (10 V)	Channel 1: ±4.2% Channel 2: ±2.5%	A
Fast transients (burst) in acc. with IEC 61000-4-4; EN 61000-4-4; 2 kV; class 3	–	B
Surge voltage in acc. with IEC 61000-4-5; EN 61000-4-5	–	B
Electrostatic discharge (ESD) in acc. with IEC 61000-4-2; EN 61000-4-2 (6 kV contact discharge / 6 kV air discharge)	–	B

Additional tolerances might occur under the influence of high-frequency electromagnetic interferences caused by radio transmission systems in the nearest vicinity. The listed values refer to the operation in the pre-setting (TC type K with cold junction compensation) for direct electromagnetic interference of the components without additional shielding such as steel cabinet, etc.

The above tolerances can be reduced by further shielding the I/O module (e.g., use of a shielded control box/ control cabinet etc.) Please observe the measures recommended in the Inline system manual for your bus system.

15.7 Process Data Update Time

(Module response time for the output of the required channel address with the corresponding measured value)

Action	Time	Number of Bus Cycles
Refreshing the measured value in the process data with a constant process data output word (e.g., PD-OUT = 0000_{hex})	< 30 ms	= Time/cycle time

The time is the response time of the module electronics up to the point in time when the valid values are present in the process data output words.